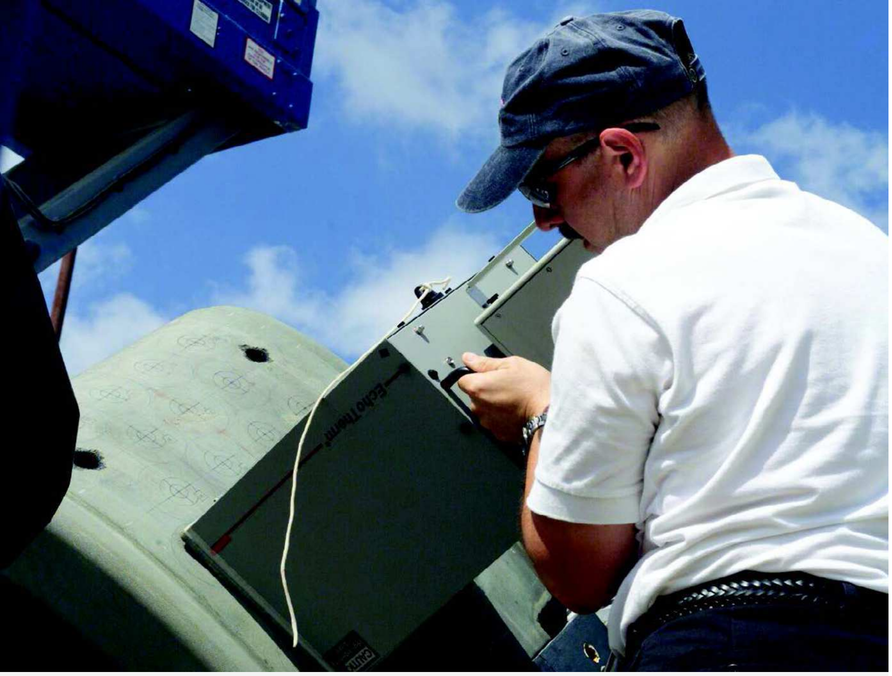

National Aeronautics and
Space Administration

Instrumentation

Method of Non-Destructive Evaluation of Composites

Using trapped energy analysis to characterize hidden damage

NASA's Langley Research Center has developed a new Non-Destructive Testing (NDT) method for identifying and characterizing hidden damage in composite materials. The new technique requires only single sided access to the test specimen and uses trapped energy analysis to detect and characterize damage that was previously obscured. Current methods, usually ultrasound or laser ultrasound, cannot characterize imperfections below or hidden by nearsurface damage. The new method uses 3D custom ultrasonic simulation tools to study ultrasonic guided wave behavior and energy trapping due to multilayer delamination damage.

Understanding the extent of composite damage is essential for repair and replacement decisions for aerospace composites. Better understanding of composite damage could eliminate unnecessary repairs and aid in preventing catastrophic in-service failure.

BENEFITS

- Improved composite damage characterization
- Detection of hidden damage
- Reduction of unnecessary repairs and replacements
- Identification of critical safety issues
- Single sided access

APPLICATIONS

- Aerospace: in-service damage assessment (e.g., fuselage collisions with ramps or baggage carts)
- Automotive: in-service inspection of composite structures
- Wind turbines: may reduce inspection time for large scale inspection of turbine blades

technology solution

THE TECHNOLOGY

Guided wavefield techniques require excitation of guided waves in a specimen via contact or noncontact methods (such as attached piezoelectric transducers or laser generation). The resulting wavefield is recorded via noncontact methods such as laser Doppler vibrometry or air-coupled ultrasound. If the specimen contains damage, the waves will interact with that damage, resulting in an altered wavefield (compared to the pristine case). When guided wave modes enter into a delaminated region of a composite the energy is split above/below delaminations and travels through the material between delaminations. Some of the energy propagates beyond the delamination and re-emerges as the original guided wave modes. However, a portion of the wave energy is trapped as standing waves between delaminations. The trapped waves slowly leak from the delaminated region, but energy remains trapped for some time after the incident waves have propagated beyond the damage region.

Simulation results show changes in the trapped energy at the composite surface when additional delaminations exist through the composite thickness. The results are a preliminary proof-of-concept for utilizing trapped energy measurements to identify the presence of hidden delaminations when only single-sided access is available to a component/vehicle. Currently, no other single-sided field-applicable NDT techniques exist for identifying hidden delamination damage.

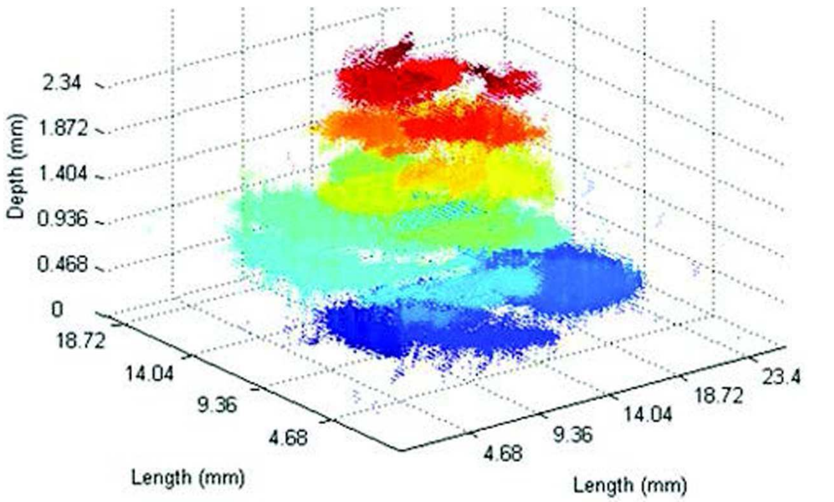

FIGURE 1 Delamination damage occurring internally in a quasi isotropic 26 ply thick CFRP plate, created by an impact (quasi static indentation). The figure shows the 3D damage map created from microfocus X-ray computed tomography scans of the plate taken at 23.4 micron resolution.

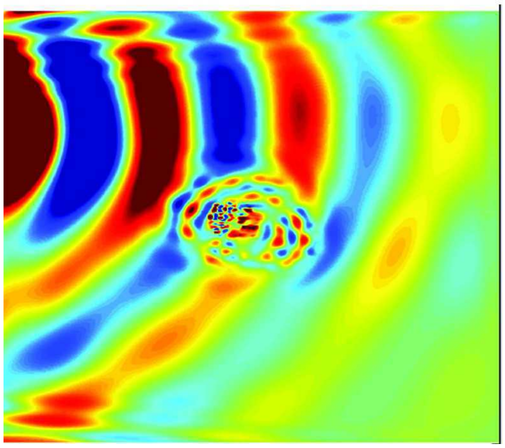

FIGURE 2 - A simulation image of ultrasonic waves interacting with delamination damage.

PUBLICATIONS

Patent Pending

More Information

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